Review of Bernard d'Espagnat, On physics and philosophy (Princeton: Princeton University Press, 2006), 503 pages, ISBN 0-691-11964-3

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Consider a Bell-type experiment such as the famous one of Aspect at the beginning of the eighties (Aspect et al. 1982): two photons are emitted together from a source and then move apart in opposite spatial directions. When the two photons are separated by a space-like interval so that there no longer is any interaction between them, spin-parameters are fixed that are to be measured on each of the two photons, and two such measurements are carried out. The measurement outcomes are correlated. However, we cannot explain the correlations by considering the state of the two particle system at the source being their common cause. Quantum physics tells us that the two systems do not 990 have a well-defined state each in separation from the other one prior to the measurement – that is to say, they do not have a definite numerical value of the spin in any direction before the measurement. Quantum physics furthermore tell us that such cases are widespread, and Bell's theorem (Bell 1964), in short, shows that they cannot be explained by assuming that each of the systems possesses some hidden intrinsic properties on which the correlations are based (local hidden variables).

This is the basis on which Bernard d'Espagnat argues in his recent books for two philosophical claims: (1) Quantum reality is nonseparable and therefore holistic. (2) We cannot know that reality. We only occasionally get a glimpse of it in experiments such as the Bell-type experiments. Quantum theory thus is important for philosophy in two respects: concerning the metaphysics of nature, it shows that nature is holistic instead of atomistic, or multitudinist, as d'Espagnat puts it. Concerning epistemology, it refutes scientific realism: we cannot know nature as it is in itself.

The book is an argument for these two claims. The first part discusses what d'Espagnat takes to be the physical facts and their conceptual implications – going into Bell's theorem (chapter 3), nonseparability (chapter 3), realism (chapters 5 to 7), decoherence (chapter 8), and the main realist interpretations of quantum physics (notably chapter 9). The second part puts these issues into a broader framework, discussing various forms of materialism (chapter 12), Kantianism (chapters 13, 17) as well as stances on causation (chapter 14), explanation (chapter 15), and consciousness (chapters 16, 18). This split is not net: the first part is not a neutral introduction, but biased towards d'Espagnat's own view.

As tempting as the link from Bell's theorem and the Bell-type experiments to nonseparability and holism and from there to our ignorance of reality in itself might be at first glance, doubts arise at closer analysis. One can distinguish three main stances in the interpretation of quantum physics in today's philosophy of physics: (a) no collapse interpretations, going back to Everett (1957); the many minds interpretation is perhaps their most prominent version today (Albert & Loewer 1988, Lockwood 1989, chapters 12 and 13): according to these interpretations, the Schrödinger dynamics is the complete dynamics of quantum systems; there hence are no state reductions, not even in measurement; all systems in the world thus are subject to entanglement. (b) collapse interpretations, of which Ghirardi, Rimini & Weber (1986) is the most prominent example: these interpretations amend the Schrödinger dynamics such that it includes state reductions as real processes occurring in

nature independently of measurement operations. (c) interpretations in terms of hidden variables, of which Bohm's theory is the most prominent example (Bohm & Hiley 1993).

According to all these three types of interpretation, there is some sort of nonseparability and thus holism in nature. On the Bohm interpretation, that holism is acknowledged in terms of the quantum potential. On the Ghirardi-Rimini-Weber interpretation, quantum entanglement (nonseparability) is fundamental, albeit limited in extension, since there are processes of state reduction. On all no collapse interpretations, nonseparability and thus holism are universal, since there are no state reductions. However, all these types of interpretations – and all their various versions – are proposals about what nature is in itself. On the no collapse interpretations, nature simply is a huge entangled quantum system; on the Bohm interpretation, nature consists in a dualism of quantum potential and particles; and on the Ghirardi-Rimini-Weber interpretation, nature in itself is characterized by entanglement, but there subsequently are processes of spontaneous localization that dissolve the entanglement. In none of these 991 interpretations is any link from nonseparability and holism to our ignorance of what nature is in itself.

D'Espagnat discusses all these interpretations in chapters 8 and 9 and dismisses them for the well-known problems each of them raises (pp. 190–192 on Everett, pp. 199–206 on Bohm, pp. 220–222 on Ghirardi, Rimini & Weber). However, any attempt at constructing a metaphysics of science will face some problems. If that fact is a reason to abandon the project of a metaphysics of science, it is no reason that has anything to do with quantum physics in particular. D'Espagnat offers nothing in his book that lives up to the conceptual clarity and precision that has been reached in setting out these three main types of the interpretation of quantum physics in today's literature. It is of no use for the philosophy of physics to simply state a claim to nonseparability and holism based on Bell's theorem and the experiments and to leave it there, claiming that because of holism, we cannot know what nature is in itself.

There are proposals for a precise conceptual analysis of quantum nonseparability and holism in the literature (e.g. Teller 1986, Howard 1989, Healey 1991, Esfeld 2001, chapter 8). These proposals are independent of the stance that one takes on the measurement problem. D'Espagnat ignores them all. They recently gave rise to a new version of structural realism as a thesis in the metaphysics of science (e.g. French & Ladyman 2003, Esfeld 2004). Ironically enough, this structural realism just is conceived as a position that avoids a gap between metaphysics (what there is in nature) and epistemology (what we can know about nature). D'Espagnat discusses structural realism, but only Poincaré's version (pp. 370–375), missing not only the recent discussion on holism and structural realism but much of the work on the conceptual analysis of the key notions he makes use of as well.

There are of course serious arguments for some version of anti-realism or other in the literature. But given the state of the art reached in the discussion on nonseparability and holism and the interpretation of quantum physics in general, it is simply conceptual confusion to take one particular physical theory – i.e., quantum physics – in distinction to other physical theories – i.e., classical physics including general relativity – to imply anti-realism.

On the one hand, the book is not suitable to move the philosophy of physics forward. On the other hand, d'Espagnat is definitely right in claiming that philosophers (and the public in general) must not ignore contemporary physics when it comes to the metaphysics of the real world (pp. 1–2 and chapter 11). A great theoretical physicist such as d'Espagnat, being able to write in an eloquent and easily accessible manner, is certainly in a position to raise the

attention to the impact quantum physics has on our attempts to understand the world within a broad audience. In that respect, the book will hopefully do a good service.

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